UDC 504.75.(477)(045)

Natalia Borul

EVOLUTION OF Cs-137 CONTENT OF PRIVATE SECTOR MILK PRODUCED IN SETTLEMENTS OF DUBROVYTSIA DISTRICT OF RIVNE REGION

National Aviation University
Kosmonavta Komarova avenue 1, 03680, Kyiv, Ukraine
E-mail: sunnystarlet@ukr.net

Abstract. *In the article a problem of radioactive contamination of private sector milk produced in Dubrovytsia district of Rivne region which is the most affected by the Chernobyl accident has been considered. The monitoring results of Cs-137 content in milk of settlements under study have been analyzed for a period of 1988-2010.*

Keywords: Chernobyl accident; Cs-137; internal radiation dose; private sector milk; radioactive contamination.

1. Introduction

A problem of radioactive contamination of the food products that are daily consumed by the North Polissia population affected by the Chernobyl accident is extraordinarily urgent today.

The level of radioecological danger for a population living on contaminated territories after the Chernobyl accident together with other factors can be essentially characterized just by the value of radioactive contamination of the products consumed by population.

Although 28 years have already passed after the Chernobyl accident, about half of Cs-137 activity passes to rural population organisms with radiocontaminated milk [2, 4, 6].

Therefore, the investigation of evolution of Cs-137 content in private sector milk, as a basic dose-forming food product for certain settlements from investigated district, is undoubtedly a vital task.

2. Literature overview

Considerable areas of Ukrainian Polissia and other territories became radiocontaminated, as a result of the Chernobyl accident.

The wide range of forms and composition of emitted radioactive substances, duration of emissions and their non-monotonic nature, weather modification resulted in complicated field patterns of the areas contaminated with radionuclides.

The structure of contaminated areas of Chernobyl origin is uneven, spotted, extended along the stream lines [5].

In turn, surface activity on radiocontaminated territories, type, composition and structure of soil as well as chemical properties of radionuclides determine the values of radionuclide contents in plant products, pasture and meadow vegetation [3].

Due to its solubility Cs-137 joins the human food chain, and, therefore population of contaminated territories gets 90 % of exposure exactly as a result of local food products consumption.

Taking into account a long half-decay period of Cs-137 (30 years), as well as a significant role of milk in a daily food ration of population residing at the territories contaminated as a result of the Chernobyl accident, the problem of Cs-137 content in milk, as a basic dose-forming factor of internal irradiation, continues to be the subject of interest for many experts [1, 4, 6, 7].

The purpose of the article is to analyse the results of radiation monitoring of Cs-137 content in milk at the most affected by the Chernobyl accident settlements of Dubrovytsia district of Rivne region.

3. Radioactive contamination of the territory of Dubrovytsia district

Radioactive contamination of a considerable amount of agricultural lands of Belarus, Russia, Ukraine and some European countries resulted from the Chernobyl accident in 1986.

Radioactive contamination of the environment and deterioration of population health, as a result of the Chernobyl accident, became the subject of scientific research for many Ukrainian and foreign scientists.

It is a leading topic of different scientific, popular science, and theoretical and practical publications.

Wide areas of six “northern” districts of Rivne region (Berezne, Volodymerets, Dubrovytsia, Rokytne, Zarichne and Sarny districts) were radiocontaminated after the Chernobyl accident.

Today, Dubrovytsia district of Rivne region still remains one of the most affected by the Chernobyl accident.

According to 1989 data about the actual radiation situation formed at the investigated area as a result of the Chernobyl accident, the average surface activity on radiocontaminated territory varied from 0.8 to 8.4 Ci/km^2.

The maximum level of soil radioactive contamination was registered in the Village of Rudnya – 13.7 Ci/km^2.

The most radiocontaminated villages were the following: Veliun – 8.4 Ci/km^2, Zagreblia – 7 Ci/km^2, Liudyn – 6.5 Ci/km^2, Partizanske – 6.2 Ci/km^2. Cs-137 content in milk exceeded a permissible level in all without exception settlements of Dubrovytsia district.

Almost all the Dubrovytsia forestry territory was radiocontaminated.

During 1989 the radiological situation control group of Dubrovytsia district Sanitary and Epidemiological Service gathered and studied a great number of samples of farm products and private sector milk.

In accordance with the data obtained throughout the above mentioned studies, it was defined that the worst radioecological situation was formed in the Villages of Budymlia, Perebrody, Myliachi, Velykiy Cheremel, Velyki Ozera, Zhaden, Shahy, Veliun, Liudyn, where there were observed high values of exceeded temporally permissible levels of radionuclide contents in food products (TPLs-88).

The monitoring results of Cs-137 content in private sector milk exactly in these settlements will be further presented in this study.

Such pattern of radioactive contamination of the given district was predefined by the fact that the forests, meadows and pastures, especially in the Polissia region on territory of which Dubrovytsia district is located, are the most dangerous territories according to the radiological indicators, as they have higher values of radionuclide's transition coefficients from soil to vegetation in comparison with arable lands and soils of other regions affected by the Chernobyl accident.

According to data collected in 2006 by Rivne Regional State Project and Technological Centre of Soil Fertility and Products Quality Protection as result of monitoring of radionuclide content in soil of control plots, agricultural lands in Dubrovytsia district with surface activity over 1 Ci/km^2 make up 6.7 thousands hectares (17.1 %), and with surface activity over 5 Ci/km^2 – 130.3 hectares (0.3 %).

The major part of radiocontaminated territories has 1-2 Ci/km^2 surface activity.

There is no doubt that surface Cs-137 activity of soils has decreased compared to 1986-1991.

It happened due to natural disintegration, carryover of Cs-137 together with a harvest, vertical and horizontal migration of radionuclide in the soil profile.

The radioactive contamination of soils in the most affected by the Chernobyl accident settlements of Dubrovytsia district of Rivne region, namely agricultural lands, pastures and woodlands in the Villages of Budymlia, Perebrody, Myliachi, Velykiy Cheremel, Velyki Ozera, Zhaden, Shahy, became the subject of our research.

It is known that sandy and peaty soils, which are characteristic for the above mentioned villages, do not promote Cs-137 fixation in soil, and, therefore, plants actively absorb radionuclides in mobile forms from the soil solution nearby root systems.

Subsequently, the population living on the territories of these settlements receives higher doses of internal irradiation due to the consumption of local food products compared to population of other settlements of Dubrovytsia district.

4. Radioactive contamination of private sector milk in settlements under investigation

For conducting investigations of Cs-137 content in private sector milk in the above mentioned settlements Sanitary and Epidemiological Service of Dubrovytsia district has a certified testing laboratory.

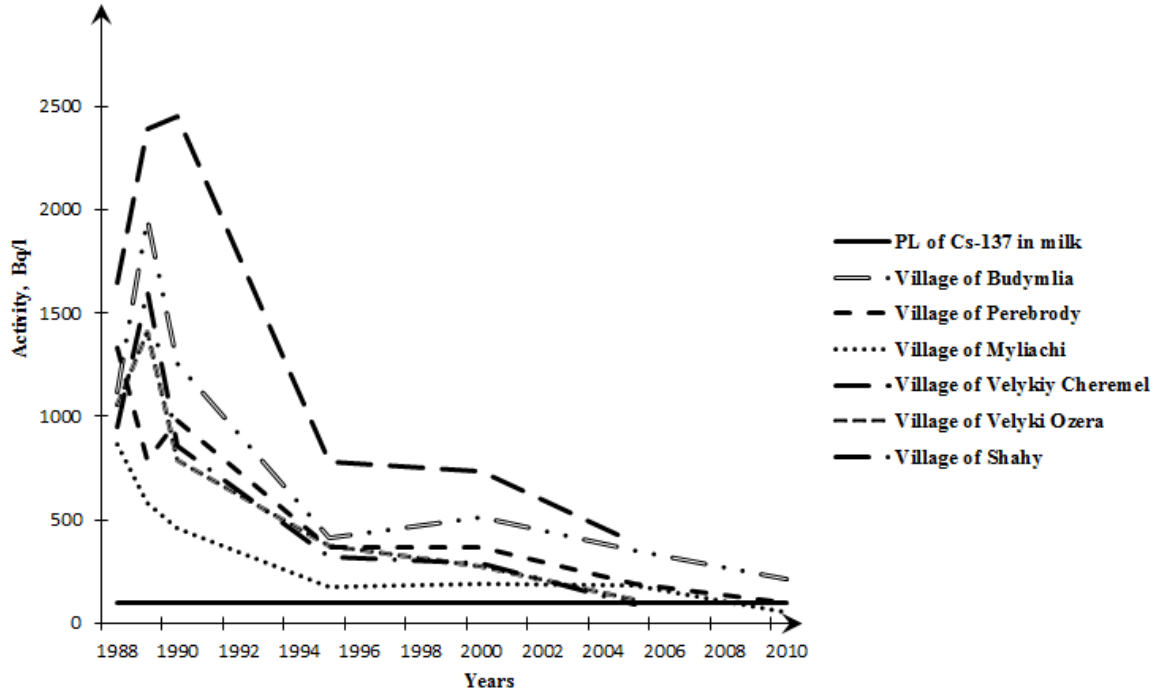
Evolution of Cs-137 content in private sector milk for the period of 1988–2010 was retraced using the results of investigation of private sector milk samples in six settlements of Dubrovytsia district of Rivne region, that are considered to be the most affected after the Chernobyl accident.

In addition, most rural residents of the given territories live in small settlements with undeveloped infrastructure, and therefore have near natural lifestyle.

The data representing Cs-137 content in private sector milk in settlements of Dubrovytsia district (Villages of Budymlia, Perebrody, Myliachi, Velykiy Cheremel, Velyki Ozera, Zhaden, Shahy) for a period of 1988–2010, are given in Table 1.

Permissible level of specific Cs-137 activity in milk according to PLs-2006 is 100 Bq/l.

Figure presents changes of the indicators of radiation environment on basis of average annual values of Cs-137 content in private sector milk samples in the most affected after the Chernobyl accident settlements of Dubrovytsia district of Rivne region.



Radioactive contamination of milk produced in settlements of Dubrovytsia district for a period of 1988–2010

The given data concerning radioactive contamination of private sector milk and its graphic interpretation allow making a conclusion that the risk associated with receipt of comparatively high doses of internal radiation due to consumption of this product by population was and still remains to be high enough.

The principal reason of large amounts of milk, content of Cs-137 in which exceeds permissible value of 100 Bq/l, is that there is no possibility in these settlements to distinguish clean pastures due to absence of corresponding areas.

In 1988, radiological situation control group at Sanitary and Epidemiological Service of Dubrovytsia district investigated 120 milk samples, obtained from six investigated settlements of Dubrovytsia district.

Levels of radioactive contamination of milk with Cs-137 were within the limits of 59.2-6031 Bq/l.

Maximum levels of radioactive contamination of private sector milk ranged from 2035 Bq/l (Village of Velyki Ozera) to 6031 Bq/l (Village of Perebrody).

In 1989, there were conducted 284 test analyses aimed at determining Cs-137 content in private sector milk in settlements under investigation.

Maximum Cs-137 content in milk reached to 7030 Bq/l (Village of Budymlia).

Average annual values of Cs-137 activity ranged from 580.6 Bq/l (Village of Myliachi) to 2391.6 Bq/l (Village of Velykiy Cheremel).

In 1990, there were conducted 126 test analyses aimed at determining radioactive contamination of private sector milk with Cs-137 in settlements under investigation.

Maximum levels of Cs-137 content in private sector milk reached values of 925-6438 Bq/l.

Average annual values of Cs-137 activity ranged from 455.6 Bq/l (Village of Myliachi) to 2449.9 Bq/l (Village of Velykiy Cheremel).

In 1995, 130 Cs-137 content analyses of private sector milk in six settlements of Dubrovytsia district under investigation were conducted.

Levels of radioactive contamination of milk with Cs-137 were within the limits of 17-1940 Bq/l.

Maximum levels of radioactive contamination of private sector milk ranged from 420 Bq/l (Village of Myliachi) to 1940 Bq/l (Village of Perebrody).

With the aim of determination of radioactive contamination rate of private sector milk with Cs-137 84 analyses were conducted in 2000.

Maximum levels of non-conformity of milk samples to permissible levels of Cs-137 were observed in the Villages of Budymlia, Myliachi and Velykiy Cheremel.

Levels of radioactive contamination of milk with Cs-137 were within the limits of 11-699 Bq/l.

Maximum values of Cs-137 activity ranged from 280 Bq/l (Village of Myliachi) to 699 Bq/l (Village of Shahy).

Table 1. Evolution of Cs-137 content in private sector milk

Settlement	Number of samples	Samples, exceeding permissible level, %	Indicators of specific Cs-137 activity in milk samples, Bq/l	
			Average value of Cs-137 activity	Maximum value of Cs-137 activity
1988				
Village of Budymlia	9	100	1114.1	2553
Village of Perebrody	47	97.9	1335.3	6031
Village of Myliachi	25	100	868	2886
Village of Velykiy Cheremel	5	100	1646.5	2923
Village of Velyki Ozera	22	100	1056	2035
Village of Shahy	8	100	952.3	2812
1989				
Village of Budymlia	93	96.8	1954.9	7030
Village of Perebrody	111	87.4	789	3774
Village of Myliachi	28	100	580.6	1369
Village of Velykiy Cheremel	18	100	2391.6	5476
Village of Velyki Ozera	19	100	1411.8	3404
Village of Shahy	15	100	1605.8	3071
1990				
Village of Budymlia	28	100	1258.4	3478
Village of Perebrody	35	94.3	976.8	3367
Village of Myliachi	12	100	455.6	925
Village of Velykiy Cheremel	10	100	2449.9	6438
Village of Velyki Ozera	24	95.8	790.1	2699
Village of Shahy	17	94.1	852.8	2349
1995				
Village of Budymlia	18	100	408.2	1060
Village of Perebrody	31	80.6	362.8	1940
Village of Myliachi	28	60.7	171.2	420
Village of Velykiy Cheremel	15	100	777.3	1140
Village of Velyki Ozera	20	90	372.2	965
Village of Shahy	18	100	321.4	982
2000				
Village of Budymlia	7	100	509	656
Village of Perebrody	–	–	365	–
Village of Myliachi	22	90.9	187	280
Village of Velykiy Cheremel	23	95.7	732	–
Village of Velyki Ozera	16	31.3	275	362
Village of Shahy	16	87.5	287	699
2005				
Village of Budymlia	5	100	351	–
Village of Perebrody	8	37.5	187	280
Village of Myliachi	15	80	180.7	320
Village of Velykiy Cheremel	12	100	391	560
Village of Velyki Ozera	16	0	114	–
Village of Shahy	16	0	91	–
2010				
Village of Budymlia	10	100	214.7	286
Village of Perebrody	9	33.3	95.2	275
Village of Myliachi	11	9.1	53.9	109
Village of Velykiy Cheremel	–	–	–	–
Village of Velyki Ozera	–	–	–	–
Village of Shahy	–	–	–	–

Average annual values of Cs-137 activity ranged from 455.6 Bq/l (Village of Myliachi) to 2449.9 Bq/l (Village of Velykiy Cheremel).

In 1995, 130 Cs-137 content analyses of private sector milk in six settlements of Dubrovytsia district under investigation were conducted.

Levels of radioactive contamination of milk with Cs-137 were within the limits of 17-1940 Bq/l.

Maximum levels of radioactive contamination of private sector milk ranged from 420 Bq/l (Village of Myliachi) to 1940 Bq/l (Village of Perebrody).

With the aim of determination of radioactive contamination rate of private sector milk with Cs-137 84 analyses were conducted in 2000.

Maximum levels of non-conformity of milk samples to permissible levels of Cs-137 were observed in the Villages of Budymlia, Myliachi and Velykiy Cheremel.

Levels of radioactive contamination of milk with Cs-137 were within the limits of 11-699 Bq/l.

Maximum values of Cs-137 activity ranged from 280 Bq/l (Village of Myliachi) to 699 Bq/l (Village of Shahy).

In accordance with the results of investigations of Cs-137 content in private sector milk in settlements under investigation in 2005, exceeding of permissible level radiocesium content was found in 44.4 % of milk samples.

Maximum values of Cs-137 content in milk ranged from 280 Bq/l (Village of Perebrody) to 560 Bq/l (Village of Velykiy Cheremel).

Average annual values of Cs-137 activity ranged from 91 Bq/l (Village of Shahy) to 391 Bq/l (Village of Velykiy Cheremel).

In 2010 30 private sector milk samples in three from six settlements under investigation (Villages of Budymlia, Perebrody and Myliachi) were analyzed.

Levels of radioactive contamination of milk with Cs-137 were within the limits of 27-286 Bq/l.

Maximum levels of radioactive contamination of private sector milk ranged from 109 Bq/l (Village of Myliachi) to 286 Bq/l (Village of Budymlia).

Taking into consideration the fact that even at present time the population of the above mentioned settlements daily consumes radiocontaminated milk (supported by the presented results of our investigation), preventive measures directed to the reduction of radionuclide contents in private sector milk is an essential precondition for improvement of radioecological situation in the given settlements of Dubrovytsia district.

5. Preventive measures for reduction of Cs-137 content in private sector milk

In fact the proper eating pattern for people living on radiocontaminated territories can reduce the intakes of radionuclides into human organism.

Meanwhile, it is important to preserve nutritional adequacy for providing of sufficient amounts in food ration all elements required for human organism:

– proteins;
– fats;
– carbohydrates;
– organic acids;
– vitamins;
– mineral substances;
– food fibre (cellulose, hemicellulose, pectin, etc.).

Taking into account the possibility of accumulation of radionuclides in milk and other dairy products, one should remember that the major part of radionuclides joins proteins and is contained in protein-lipid shells.

Therefore Cs-137 content is lower in dairy products which contain fat in high amounts and low protein content, and visa verse [1].

Significance of different technologies of receipt of dairy products in order to reduce radionuclide content in them is presented in Table 2.

Table 2. Transition of Cs-137, % by content in unskimmed milk

Dairy products	Cs-137
Unskimmed milk	100.0
Skimmed milk	85.0
Cream	15.0
Butter	2.5
Buttermilk	13.5
Butterfat (melted butter)	0
Skimmed cottage cheese	10.0
Casein	1.6

For that very reason, it is recommended to make a cream, butter, sour cream, and cottage cheese from radiocontaminated milk.

A considerable part of radionuclides transfers from milk to whey when obtaining the above mentioned dairy products [3].

Thereby, technological and culinary processing of milk, directed to reduce radionuclide content, will help to minimize a risk associated with high doses of internal radiation exposureof human organism.

6. Conclusions

The results of our investigation confirm the fact of essential radioactive contamination of private sector milk in six settlements of Dubrovytsia district under investigation, that are considered to be the most affected after the Chernobyl accident.

Therefore, we can conclude that private sector milk during the entire period of 1988–2010 and also at present time is the main contributor to forming of annual effective doses of internal irradiation of population living on the territories of settlements under investigation.

At the same time, on basis of non-threshold conception assumed as a basis of optimization principle, accepted in the system of radiation safety, it is necessary that these doses tend to be as lower as possible.

Setting of monitoring of radioactive contamination of private sector milk in settlements under investigation (taking into consideration insufficient number of milk samples obtained by radiological situation control group at Sanitary and Epidemiological Service of Dubrovytsia district during a period of 1988–2010), for recording of reliable values of Cs-137 content in milk and dose management for minimization of doses of internal irradiation that are formed in population as a result of radiocontaminated milk consumption.

Certainly one of the most effective measures for internal irradiation prevention is to provide population with clean, in a radiological sense, food products.

It can be achieved by carrying out of thorough radiation control of all agricultural production and exception from the food ration of those foodstuffs levels of contamination of which exceed permissible levels.

Milk separation through ferrocene filters, that reduces Cs-137 content in milk by minimum 10 times, is a real measure to provide clean milk for this region.

References

[1] *Babyuk, A.V.* Contamination of the foodstuffs with radionuclides, pesticides, and nitrates. Chernivtsi. 2007. 57 p. (in Ukrainian).

[2] *Gudkov, I.M.; Gaychenko, V.A.; Kashparov, V.O.; Kutlahmedov, Yu.O.; Lazaryev, M.M.* Radioecology. Kyiv. 2011. 368 p. (in Ukrainian).

[3] *Mashchenko, M.P.; Hamenko, I.M.; Sysoyenko, N.V.* Radioactive contamination of the foodstuffs at nuclear accidents and the main ways of its reduction. Medical perspectives. 2003. N 2. P. 133–136 (in Ukrainian).

[4] *Nesterenko, V.B.* Radiation monitoring of residents and their foodstuffs in the Chernobyl zone of Belarus. Part 1. Gomel region. Bragin district. Newsletter. N 29. Part 1. Minsk. 2006. 124 p. (in Russian).

[5] *Pavlovskyi,V.A.; Korbut, G.O.; Gnenna, L.F.; Pamirskyi,M.S.; Ivanova, A.I.; Miroshnychenko, A.I.* Problems of improvement of health state of children in Zhytomyr region after the Chernobyl accident. Ecological consequences of radioactive contamination. 2007. N 5. P. 18–22 (in Ukrainian).

[6] *Sudas, A.S.; Grygoryev, G.K.; Sechkov, L.M.* Evaluation of the change of radiation situation in districts of Brest region according to the data of radioactive contamination of the milk. International Conference on Socio-economic Problems of the Development of Byelorussian Polesye Region, February 7-8. 2002. Minsk. BSEU. P. 116–120 (in Russian).

[7] *Toader, M.; Vasilache, R.A.* Evolution of ^{137}Cs and ^{90}Sr content of the main foodstuff in Bucharest Area after the Chernobyl accident. One decade after Chernobyl: Summing up the consequences of the accident Poster presentations. IAEA. Vienna. 1997. Vol. 2. P. 41–47.

Received 23 June 2014.

Н.В. Боруль. Динаміка вмісту Cs-137 в молоці приватного сектору населених пунктів Дубровицького району Рівненської області
Національний авіаційний університет, просп. Космонавта Комарова, 1, Київ, Україна, 03680
E-mail: sunnystarlet@ukr.net

Розглянуто одну з найбільш важливих проблем радіоактивно забруднених територій унаслідок Чорнобильської катастрофи – радіоактивне забруднення молока приватного сектору як основного дозоутворюючого продукту харчування. Установлено роль радіоактивно забрудненої продукції, що споживається населенням, у формуванні дози внутрішнього опромінення населення, а отже й у визначенні рівня радіоекологічної небезпеки для населення, яке проживає на забруднених радіоактивними речовинами територіях. Наведено дані радіаційного моніторингу територій найбільш постраждалих у результаті Чорнобильської катастрофи населених пунктів досліджуваного району, отримані групою контролю за радіологічною обстановкою за 1988–2010 рр. Проаналізовано профілактичні заходи щодо зменшення вмісту радіонуклідів у молоці, оскільки їх застосування є вагомою передумовою покращення радіоекологічної обстановки в досліджуваних населених пунктах.
Ключові слова: доза внутрішнього опромінення; молоко приватного сектору; радіоактивне забруднення; Чорнобильська катастрофа; Cs-137.

Н.В. Боруль. Динамика содержания Cs-137 в молоке частного сектора населенных пунктов Дубровицкого района Ровенской области
Национальный авиационный университет, просп. Космонавта Комарова, 1, Киев, Украина, 03680
E-mail: sunnystarlet@ukr.net

Рассмотрена одна из наиболее важных проблем радиоактивно загрязненных территорий в результате Чернобыльской катастрофы – радиоактивное загрязнение молока частного сектора как основного дозоформирующего продукта питания. Установлена роль радиоактивно загрязненной продукции, потребляемой населением, в формировании доз внутреннего облучения населения и, следовательно, в определении уровня радиоэкологической опасности для населения, проживающего на загрязненных радиоактивными веществами территориях. Приведены данные радиационного мониторинга территорий, наиболее пострадавших в результате Чернобыльской катастрофы населенных пунктов исследуемого района, полученные за 1988-2010 гг. группой контроля радиологической обстановки. Проанализированы профилактические меры относительно уменьшения содержания радионуклидов в молоке, так как их применение является весомой предпосылкой улучшения радиоэкологической обстановки в исследуемых населенных пунктах.
Ключевые слова: доза внутреннего облучения; молоко частного сектора; радиоактивное загрязнение; Чернобыльская катастрофа; Cs-137.

Borul Natalia. Postgraduate student.
Ecology Department, National Aviation University, Kyiv, Ukraine.
Education: National Aviation University, Kyiv, Ukraine (2012).
Research area: radioecological safety.
Publications: 4.
E-mail: sunnystarlet@ukr.net